

DeltaV: Adding Versioning to the Web

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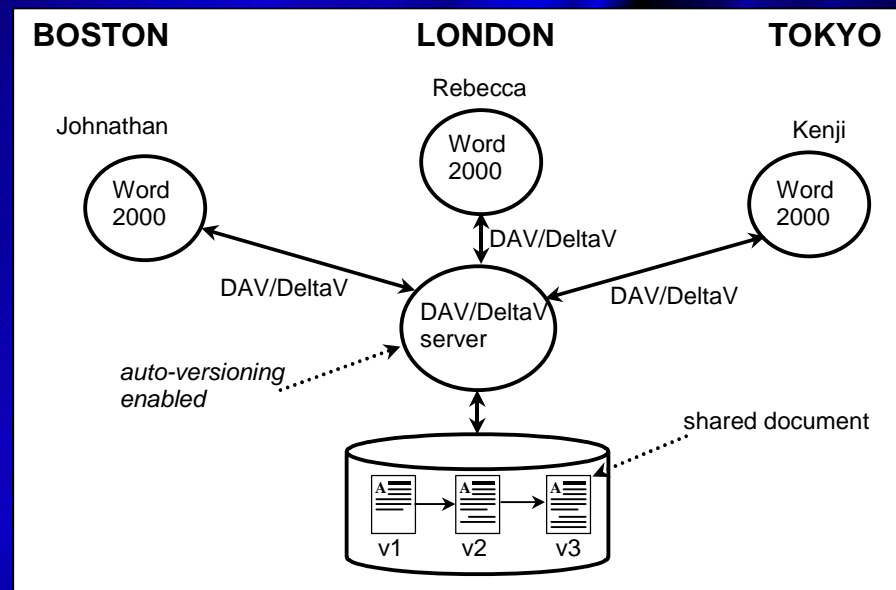
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Documents Change

- Documents **change over time**
 - Web pages
 - Word processing documents
 - Spreadsheets
 - Images
 - ...all are typically created via an **iterative authoring process**
- Document change tracking is desirable
 - Undo a mistake
 - Know **who** made a change, and **when**
 - Record **why** a change was made
- Change tracking provides
 - Greater *control* over change
 - An *archive* of past document states

Remote Collaborative Document Authoring Scenarios

- A task force of people from geographically dispersed business units need to develop a report together.
 - Team needs to solicit feedback, so they send out copies of the report.
 - As a result, the team needs a permanent copy of the exact report version they are having other people review.



Other Remote Collaboration Scenarios

- **Cross-company collaboration project**
 - Multiple companies, several countries.
 - Remote authoring of project Web site
 - Using a WebDAV-aware tool, such as Go Live, or Dreamweaver.
 - Since any project member can edit the Web site contents, the team wants to keep track of all changes
 - Records **who** changed **which** page
 - If mistakes are made, changes can be undone
- **Open source software project**
 - Team members from around the globe
 - Need to **record code changes**
 - Maintain **stable baselines** of public releases
 - Developers need to edit and compile source code on their local machine

WebDAV/DeltaV: In Support of Collaboration

- To support the collaboration scenarios, there is a need for a standard that supports:
 - Remote authoring of all types of documents
 - Web pages, word processing, spreadsheets, presentations...
 - Change tracking for these documents
 - Prevents collaborators from clobbering each other's work
 - Simultaneous work, in isolation from each other's changes
 - Recording stable baselines comprised of multiple documents
 - Recording information about documents (metadata)
- Which also...
 - Is supported by major tools
 - Is integrated into the Web
 - Is easy to use
- WebDAV and DeltaV do all this and more!

What is DeltaV?

- DeltaV is:
 - An application layer network protocol
 - Extends the WebDAV protocol
 - WebDAV itself extends HTTP 1.1
 - Thus DeltaV is also an extension to HTTP 1.1
 - HTTP is the core network protocol of the Web
 - An interoperability standard
 - Allows document authoring and software development applications to **interoperate** with versioning and configuration management systems using a **common interface**
 - A data model
 - DeltaV embodies a data model that is capable of modeling multiple versioning and configuration management repositories
 - The data model is independent of network protocol
 - A data integration infrastructure
 - A common place for cross-application data sharing

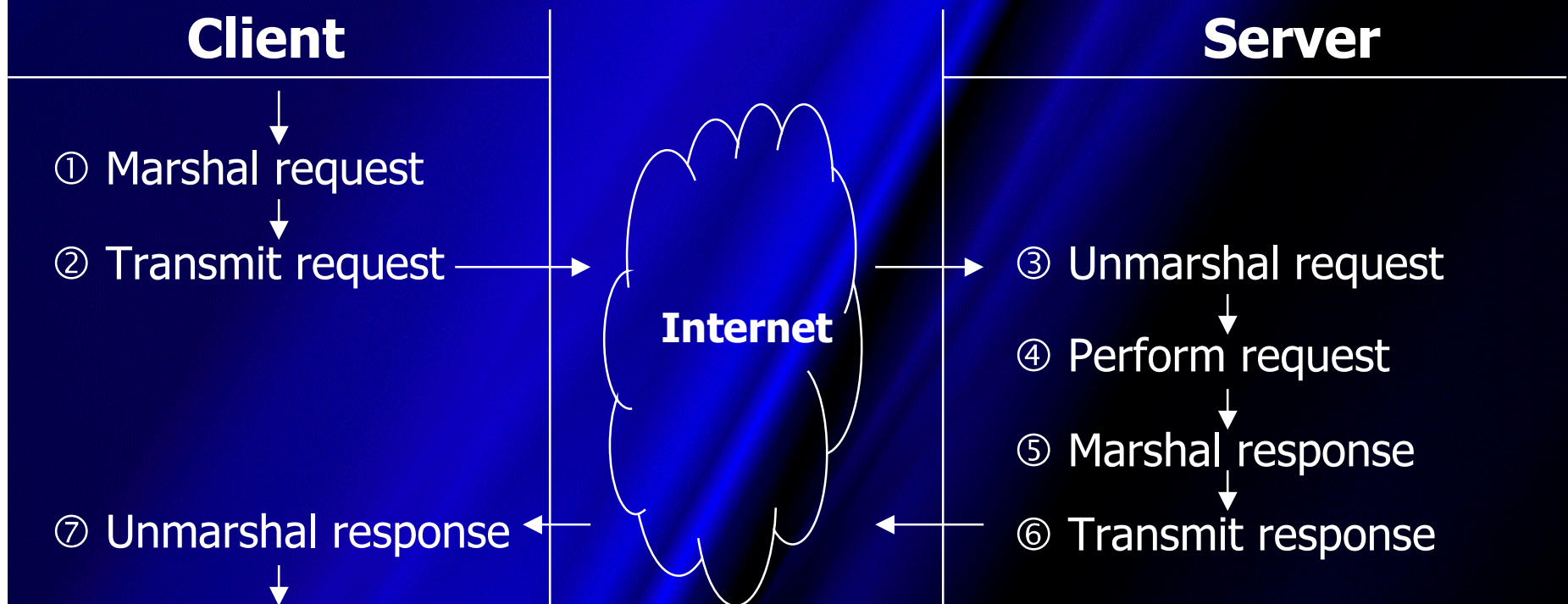
Who is DeltaV?

- DeltaV is an **IETF** Working Group
 - IETF: Internet Engineering Task Force
 - Developed standards such as TCP, IP, SMTP, POP, FTP
 - Typical IETF & W3C spheres of standardization:
 - IETF: network protocol and identifier standards (HTTP, URL)
 - W3C: content standards (HTML, CSS, XML, XSS, RDF)
- IETF considers its working groups to consist of individual contributors, not corporate representatives
 - Anyone may join an IETF working group
 - Agreement is by rough consensus: no voting
- Still, corporate affiliations can be informative:
 - Chair: Jim Amsden, IBM
 - Document authors include Geoff Clemm, Rational, Chris Kaler, Microsoft
 - Other participants: Merant, Intersolv, OTI

Hypertext Transfer Protocol (HTTP)

Briefly, HTTP

- HyperText Transfer Protocol (RFC 2616)
- A **remote procedure call** protocol
 - Client sends a request to the server
 - Server processes request, and returns result



HTTP Request Format

- A request line:
 - {method} {Request-URI} {protocol version}
 - Example:
 - GET /users/ejw/flyer.doc HTTP/1.1
- A series of headers:
 - {header}: {value}
 - RFC 822 (email) style header encoding
 - Example:
 - Content-Type: text/html
- An optional request body
 - Separated from headers by a <CR><LF>
 - A sequence of 8-bit bytes (octets)

HTTP Response Format

- Very similar to the request format:
- A status line:
 - {protocol version} {status code} {status phrase}
 - Status codes:
 - 1xx: Informational
 - 2xx: Successful
 - 3xx: Redirection
 - 4xx: Client error
 - 5xx: Server error
 - Example:
 - HTTP/1.1 200 OK
- A series of headers
 - Same formatting as in request
- A response body
 - Same formatting as in request

Sample HTTP interaction

Request

GET / HTTP/1.1
Host: www.webdav.org
Content-Length: 0

Response

HTTP/1.1 **200 OK**
Date: Wed, 25 Apr 2001 22:58:22 GMT
Server: Apache
Last-Modified: Thu, 19 Apr 2001 05:30:49 GMT
ETag: "30e7da-2f9d-3ade7809"
Accept-Ranges: bytes
Content-Length: 12189
Content-Type: text/html

*<!DOCTYPE HTML PUBLIC "-//IETF//DTD HTML//EN">
<html>
 <head>
 <title>WebDAV Resources</title>*

Important HTTP 1.1 Concepts

- Requests are transmitted over a **reliable transport**
 - Invariably, this is TCP/IP
- Network connection is left **open** at the end of a request
 - Uses the network more efficiently
- **Stateless protocol**: all information needed to process a request is contained in the request
- **Entity tag** is a unique identifier for the state of a resource
 - If the GET response body changes, so does the Etag
 - Useful for determining if the resource has changed
 - Should a cache update its value?
 - Did someone modified this resource while I was editing it?

HTTP Methods

- Operations supported by HTTP include:
 - GET – read a resource
 - HEAD – just return headers about a resource
 - Useful for caching (quickly retrieve entity tag)
 - OPTIONS – lists supported methods
 - POST – protocol-tunneling method
 - PUT – write a resource
 - DELETE – remove a resource
- Although HTTP 1.1 supports PUT and DELETE, it is primarily a read-only protocol
 - PUT and DELETE are not widely supported by clients

Web Distributed Authoring and Versioning (WebDAV)

WebDAV

- The goal of WebDAV is to add capabilities for remote authoring and versioning to HTTP
 - But, the versioning part was dropped in order to finish the remote authoring protocol
 - RFC 2518 is the defining document for WebDAV
 - DeltaV picked up where WebDAV left off
 - The changes (Δ) needed to add the "V" back into WebDAV
- WebDAV capabilities include:
 - **Overwrite prevention:** lock, unlock
 - **Properties:** list, add, remove
 - **Namespace Operations:** move, copy
 - **Collections:** mkcol, hierarchy operations

Collaboration Infrastructure

- Whole resource locking supports:
 - Remote collaborative authoring of HTML pages and associated images
 - Remote collaborative authoring of any media type (word processing, presentations, etc.)
 - Locks time out, easing administration of locks
- *Infrastructure* for development of asynchronous, widely distributed, hypertext-aware, collaborative editing tools.

Metadata Recording Infrastructure

- Metadata support
 - ***Properties.*** (name, value) pairs can be created, modified, deleted, and read on Web resources.
 - Consistency of properties can be maintained by the server or the client
 - Property values are well-formed Extensible Markup Language (XML)
- *Infrastructure* for how to record information *about* Web data

Namespace Management Infrastructure

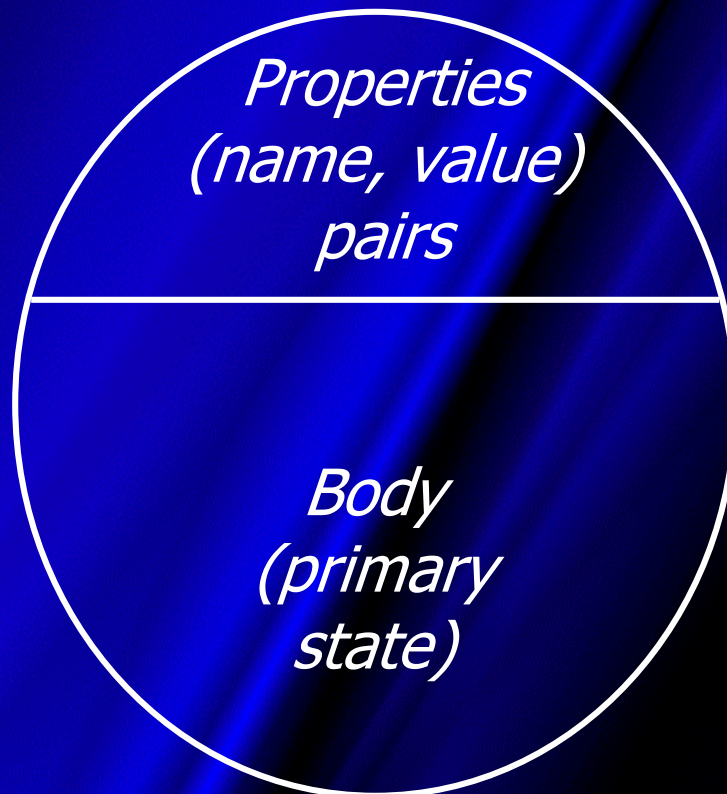
- Remote name space management:
 - Copy and Move individual resources, and hierarchies of resource
 - Create and modify (ordered) collections of resources
 - Add/remove members by-reference
- *Infrastructure* for remotely organizing and viewing collections of Web resources

WebDAV Methods

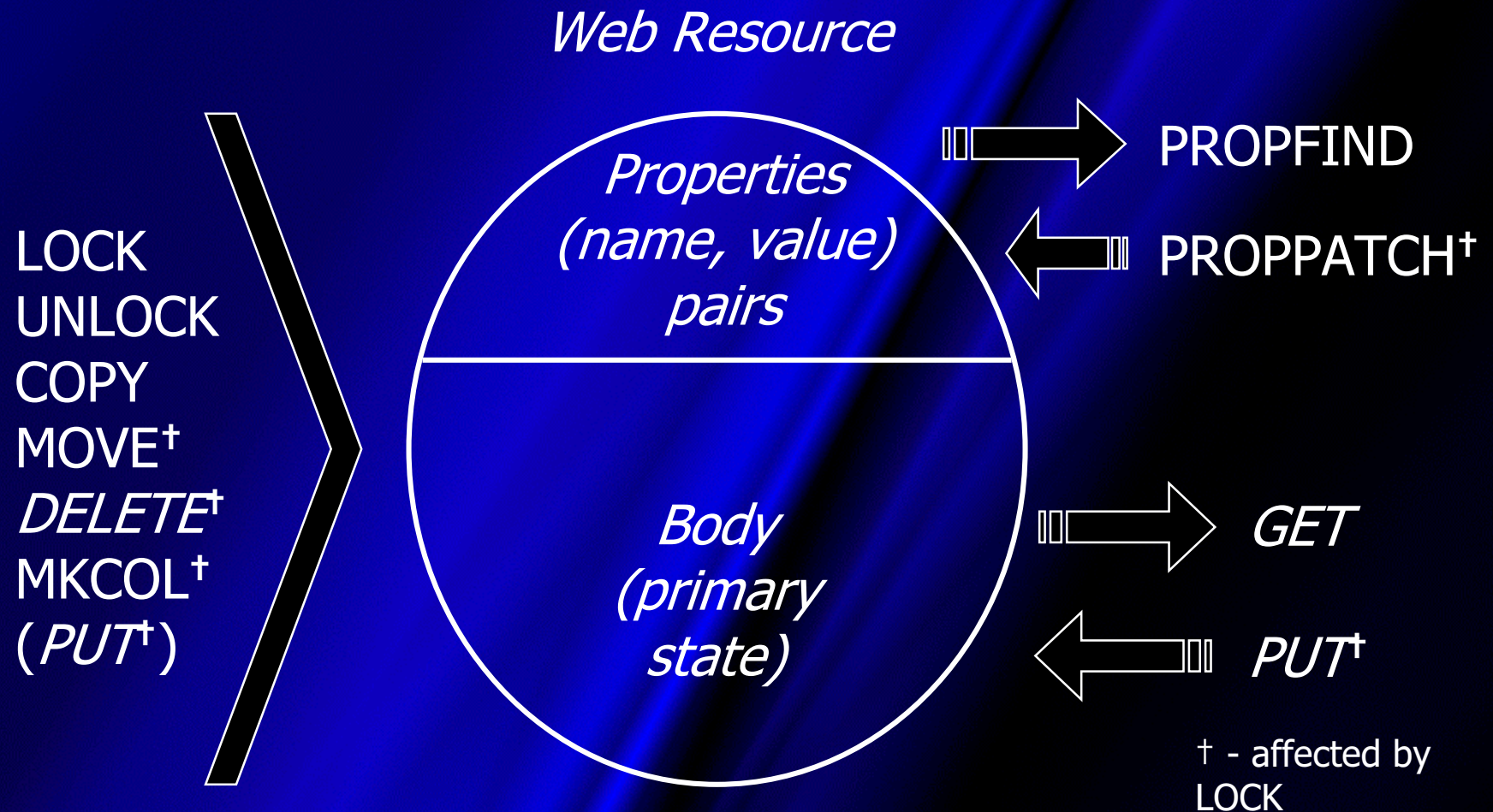
- **Overwrite Prevention:**
 - LOCK – prevents non-lock holders from writing to the resource
 - UNLOCK – removes a lock
- **Metadata Management:**
 - PROPFIND – read properties from a resource
 - Allprop – all property names and values
 - Propname – only return property names
 - Prop – just return specified properties
 - PROPPATCH – write properties on a resource
- **Namespace Management**
 - COPY – duplicate a resource
 - MOVE – move a resource (preserving identity)
 - MKCOL – create a new collection

WebDAV Object Model

Web Resource



Scope of WebDAV Methods



Major WebDAV Servers

Microsoft: IIS 5, Exchange 2000, Sharepoint

Apache: mod_dav (over 10,000 sites)

Oracle: Internet File System

Adobe: InScope

Xythos: Storage Server

Novell: Netware 5.1, Net Publisher

W3C: Jigsaw

Endeavors: Magi-DAV

IBM: DAV4J (DeveloperWorks)

DataChannel: DataChannel Server (DCS 4.1)

Intraspect: Knowledge Server

OpenLink: Virtuoso

Hyperwave: Information Server 5.5

Major WebDAV Clients

- Application Software:
 - **Microsoft:** Office 2000 (Word, Excel, PowerPoint, Publisher)
 - **Adobe:** Photoshop 6, Acrobat 5
- Web Site Authoring
 - **Adobe:** Go Live 5
 - **Macromedia:** Dreamweaver 4
- Remote File Access:
 - **Apple:** Mac OS X webdavfs
 - OS X also ships with Apache and mod_dav (have to configure mod_dav to make it work)
 - **Microsoft:** Windows Web Folders
 - **Wind River Software:** WebDrive
 - Goliath (Mac, open source)
 - Nautilus (GNOME project, Eazel)
 - WebDAV Explorer (UC Irvine, Feise/Kanomata, open source)
- XML editors
 - **ExcOSOFT:** Documentor
 - **Altova:** XML Spy 3.5

Versioning Terminology and Data Model

Version History

**URL path of
Versioned
Controlled
Resource**

→ Foo.htm

**Branch
Version
Name**

Label

Successor

initial ①

Beta1 ②

③

④

Test1 ⑤

Beta2 ⑦

**Line of
Descent**

**Revision
History**

Merge

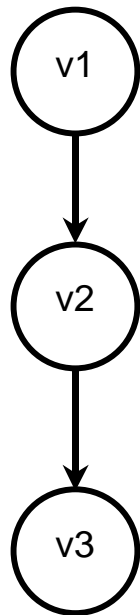
Predecessor

Placing a resource under version control

- VERSION-CONTROL puts an unversioned resource under version control
- VERSION-CONTROL does three operations:
 1. Creates a new **version history resource**
 - A list of URLs of the versions in this revision history
 - The URL of the root version
 2. Creates a new **version resource**
 - Predecessor and successor identifiers stored in properties (initially empty)
 - URL is **not** the same as the original unversioned resource
 3. Converts the unversioned resource into a **version controlled resource**
 - URL is the **same** as the original unversioned resource
 - Has a pointer to the version history resource
 - Records whether it is checked-out or checked-in

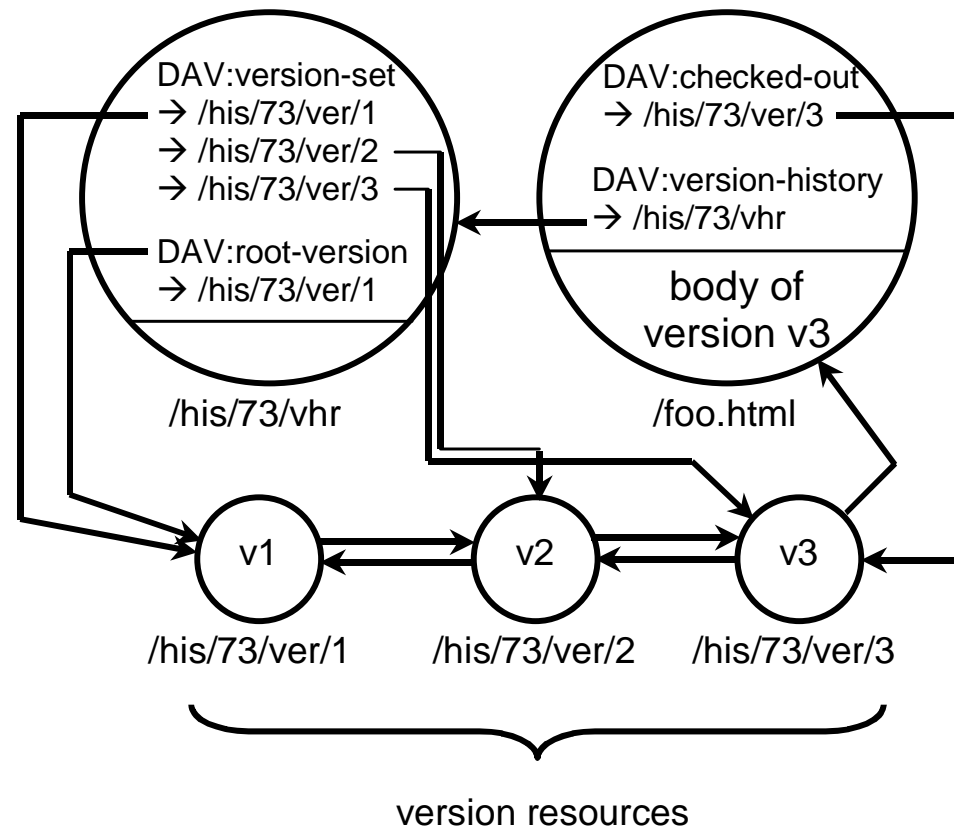
Representation of a Version History

Abstract version history of foo.html



Representation of foo.html in DeltaV

version history resource version-controlled resource



Unique Aspects of Versioning Data Model

- DeltaV data model is different from RCS/SCCS model
 - RCS: placing foo.html under version control causes:
 - foo.html to be made read-only
 - Creation of RCS/foo.html,v archive file
 - Archive contains version history and version data
 - Differences
 - Both use the original name as the place where commands are directed
 - But, version-controlled resource has more metadata
 - DeltaV separates version history from version storage
 - DeltaV gives each version a unique identifier (URL)
 - Note that delta storage can still be used in the underlying repository

Rationale for Versioning Data Model

- Each version is given its own URL, thus allowing hypertext linking to a specific version.
 - Hence, each version must be a separate resource
- Workspaces are the motivation for separating the version-controlled resource from the history resource.
 - A workspace allows a collaborator to work in isolation, in their own part of the namespace.
 - For example, Greg and Lisa might have workspaces:
 - /ws/users/greg/ and /ws/users/lisa/
 - If both want foo.html to appear in their local workspace, **each needs a version controlled resource.**
 - Thus, one version history can be associated with multiple version controlled resources.

Versioning Operations

CHECKOUT

- DeltaV uses the library metaphor for versioning.
 - To work on a resource, you:
 - Check out
 - Make edits
 - Check in
- CHECKOUT is applied to a version controlled resource
 - Allows modifications to the body and dead properties of the version controlled resource
 - If a version is already checked-out, or has a successor (is non-tip), a fork (branch) is possible.
 - DAV:checkout-fork property on a version affects branch formation
 - ok: branching is permitted
 - discouraged: the client must explicitly indicate branching is OK
 - forbidden: branching is not allowed (linear version history)

CHECKIN / UNCHECKIN

- CHECKIN freezes the state of a version controlled resource:
 - Creates a new version resource
 - Body and dead properties are the same as those of the version controlled resource
 - Freezes the body and dead properties of the version controlled resource (making them read-only)
 - A comment describing the purpose of a change can be written into the *DAV:comment* property (before CHECKIN)
 - Fork control options are available on CHECKIN as well
- UNCHECKOUT aborts the editing sequence
 - Cancels the CHECKOUT
 - Restores the pre-CHECKOUT state of the version controlled resource

Autoversioning

- There are many WebDAV-aware applications
 - They know nothing about versioning!
 - Would like to provide **automatic versioning** support
- Two styles of autoversioning:
 1. Every modification creates a new version
 - PUT/PROPPATCH ⇔ CHECKOUT → PUT/PROPPATCH → CHECKIN
 - Works best for authoring clients that replicate resources to a local disk, and only write to the server at the end of an editing session.
 2. Every LOCK/UNLOCK pair creates a new version
 - LOCK ⇔ LOCK → CHECKOUT
 - UNLOCK ⇔ CHECKIN → UNLOCK
 - Works well for authoring clients that work directly on the WebDAV server and take out locks, like Office 2000.
- Style is controlled by *DAV:autocheckout* and *DAV:autocheckin* properties on version controlled resource

Labels

- **Human-readable** strings that can be attached to a particular version
- **Guaranteed uniqueness** within a version history
- Can be **reused** across version histories
 - For example, “release_beta” could be used to identify different versions in multiple version histories
 - Can be used as a simple way to record configurations
 - Drawback: the mapping of labels to versions can change over time, so configurations are not guaranteed to be stable
- LABEL method is used to set/move/remove a label on a version
- Label: header can be used with GET/PROPFIND on a version controlled resource to retrieve information from the named version.

UPDATE

- Body and dead properties of a version controlled resource are typically the same as the last checked-in version
 - In a linear version history, the version controlled resource typically tracks the tip version
- UPDATE
 - Modifies the content and dead properties...
 - ... of a checked-in version-controlled resource
 - ... to be those of a specified version from the version history
- Benefit: An **arbitrary version** can be reflected by the version controlled resource.

Merging

- Branches in a version history are used for two purposes:
 - Representing simultaneous development by multiple collaborators (parallel development)
 - Representing variants of a resource
 - Natural language, computing platform, etc.
- It is useful to merge together branches that represent parallel development
 - Combine the efforts of multiple people into a consistent whole
- MERGE combines two versions
 - Minimally combines the two branches in the version history
 - Performs a best-effort content merge if the server understands the content type of the two versions
 - text/* merging will likely be the only types uniformly supported

Version Tree Report

- A **graphical visualization** of a version history aids understanding
 - Information needed to create this view:
 - List of versions
 - Version names
 - Predecessor/successor relationships
 - In DeltaV data model, information is distributed:
 - Version history resource: list of versions
 - Version resources: version names, pred/succ relationships
 - Using PROPFIND, would require N+1 network requests in the worst case (N=# of versions)
 - REPORT method supports many kinds of reports
 - **Version tree report** allows arbitrary properties to be requested from all versions of a version history
 - *DAV:version-name* & *DAV:successor-set* properties
 - Now, only one network request is needed

Activities

Purpose and Definition

- Frequently, a logical change spans multiple versions in multiple version histories
 - For example, fixing a specific software bug can involve the creation of multiple versions of several files
- Activities associate a logical change with the set of versions created while making that change.
 - Versions from a given version history are **limited to a single line of descent**
 - Activities are not versioned
- Sometimes want to ensure that all work done by team members is on a single line of descent
 - Avoids merging between team members
 - Activities can be used to enforce working on just a single line of descent

Working with Activities

- MKACTIVITY creates a new activity resource
- Upon checkout, the author specifies an activity
 - This activity is associated with the new version created at checkin
 - Specifically:
 - URL of the checked-out resource is stored in activity's *DAV:activity-checkout-set* property
 - On checkin, the new version's URL is recorded in activity's *DAV:activity-version-set* property...
 - ... and the checked-out resource is removed from *DAV:activity-checkout-set*
- Using activities, it is possible to select a particular logical change for merging into another workspace
 - The activity is used in a MERGE request
 - Latest version in an activity (for each version history) is the one used in the merge

Latest Activity Version Report

- Since an activity only records a set of version URLs, determining the latest version in an activity would require:
 - Retrieving the list of versions in an activity
 - Determining the associated set of version histories
 - Retrieving the version tree report for each version history
 - Evaluating the version graphs to determine which of the activity versions is the latest
- The latest activity version report returns the latest version in an activity, for one version history
 - REPORT is invoked on a version history resource
 - Passes URL of an activity resource

Workspaces

Purpose and Definition

- A **workspace** is a location...
 - ... where a person can work **in isolation**
 - ... from **ongoing changes** made by other collaborators
 - to the **same set** of resources.
- Workspace use scenarios:
 - Two people each modify a common source code file, and want to test their work before integrating changes
 - The directory structure of a large project is being changed
 - Don't want to require everyone to stop working while this takes place
 - Keep namespace changes invisible to team until complete
 - A developer is trying a change that might not pan out
 - New files are in their workspace, but not under version control until the final viability of the change is known

Workspaces

- Two kinds of workspaces: server and client
 - Main difference is whether the server maintains a portion of its namespace for each workspace
- Workspaces can hold versioned and unversioned data

Server workspaces

- Maintains a separate namespace for each workspace
- For example: Lisa and Chuck both have workspaces
 - Lisa's: /users/people/**lisa**/projectX/...
 - Lisa does all her work in this tree
 - Chuck's: /users/people/**chuck**/projectX/...
 - Chuck does all his work in this tree
- Local replication of versions may still occur
- Advantages
 - Permit access from multiple locations and machines
 - Permit namespace operations (like MOVE) to be isolated
- Disadvantages
 - Requires significant manipulation of the server namespace
 - Might be tricky to implement for filesystem-based repositories

Client workspaces

- No server namespace is maintained
- Working files are replicated to local machines
- Server reserves a **working resource** for each checkout
 - When the edit session is done, data is written to the working resource
- Advantages
 - Less use of server namespace
 - Close match to CVS replicate-work-synchronize work pattern
- Disadvantages
 - Cannot access workspace from multiple machines and locations
 - Namespace operations are immediately visible

Server Workspace Mechanics

- MKWORKSPACE creates a new workspace resource
 - This is the top-level directory of the project
 - E.g., /users/people/lisa/projectX/
- VERSION-CONTROL adds version controlled resources to a workspace
 - Creates a new version controlled resource for a version history
 - The version history will have **multiple** version controlled resources
 - Think of the version controlled resource as the access point, at some location in the namespace, for operations on a version history.

Synchronizing Workspaces

- At some point in time, a person working in a workspace will need to bring in changes made by other collaborators.
- MERGE combines two workspaces
 - Typically, the source of the merge is the common project workspace, and the destination is a personal workspace
 - MERGE acts to select the most recent checked-in version for each version-controlled resource in the workspace
- A client may want to present the outcome of a workspace merge before it is actually performed
 - Allows the user to decide if they like the outcome
 - The **merge-preview** report describes the changes that would occur due to a MERGE operation
 - Invoke it using REPORT

Server Workspace Example

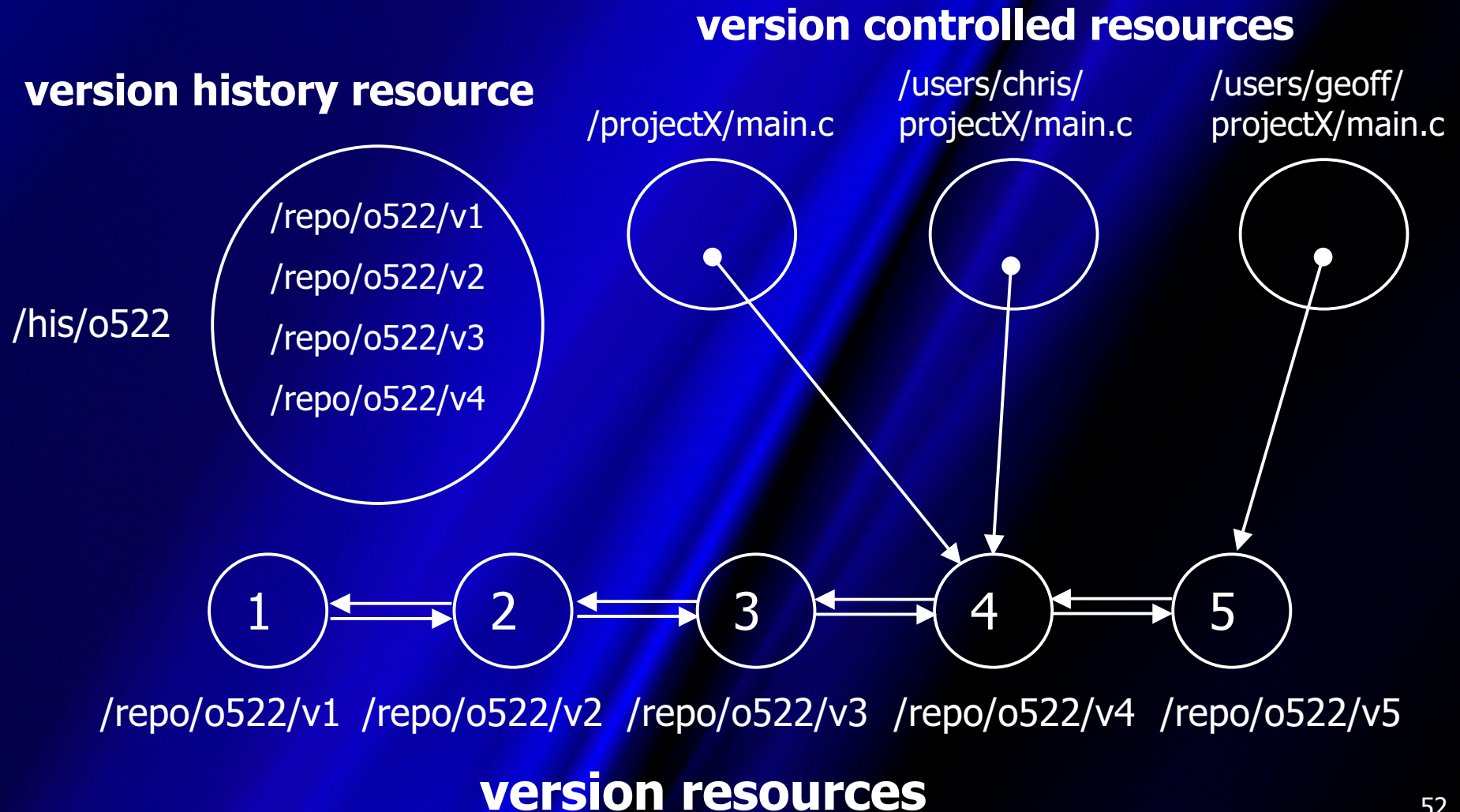
- Consider a program with the following source files:
 - `/projectX/makefile`
 - `/projectX/main.c`
 - `/projectX/defs.h`
- Geoff and Chris want to collaborate together on this project
 - Each person works in a separate server-side workspace
- Create the workspaces:
 - `MKWORKSPACE /users/geoff/projectX/`
 - `MKWORKSPACE /users/chris/projectX/`

Server Workspace Example (2)

- Use version control to add project files:
 - Populate Geoff's workspace:
 - `VERSION-CONTROL /users/geoff/projectX/makefile` from `/projectX/makefile`
 - `VERSION-CONTROL /users/geoff/projectX/main.c` from `/projectX/main.c`
 - `VERSION-CONTROL /users/geoff/projectX/defs.h` from `/projectX/defs.h`
 - Populate Chris' workspace:
 - `VERSION-CONTROL /users/chris/projectX/makefile` from `/projectX/makefile`
 - `VERSION-CONTROL /users/chris/projectX/main.c` from `/projectX/main.c`
 - `VERSION-CONTROL /users/chris/projectX/defs.h` from `/projectX/defs.h`

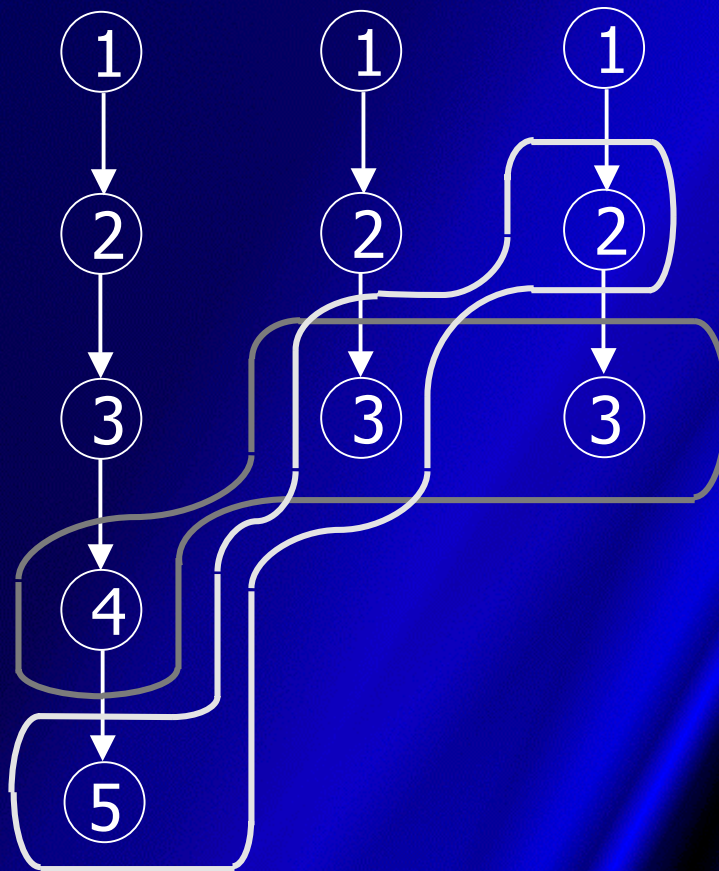
Server Workspace Example (3)

- Version history of main.c:



Server Workspace Example (4)

main.c makefile defs.h



/users/geoff/projectX/
main.c, 5
makefile, 3
defs.h, 2

/users/chris/projectX/
main.c, 4
makefile, 3
defs.h, 3

Client Workspaces

- Client maintains control over namespace of the locally replicated data
 - Server is required to maintain very little state
- Working resource
 - Created upon checkout
 - A location on the server where the client can write the contents of the checked-out resource
 - Goes away upon checkin
 - CHECKIN converts working resource into a version resource
 - A version history can have multiple simultaneous working resources

Client Workspace Example

- Assume work on file main.c:
- 1. Client first replicates a version of main.c using GET
 - Result is stored under a local name:
 - /{local workspace name}/main.c
- 2. Then, client uses CHECKOUT to checkout the same version
 - Creates a working resource
 - URL of working resource found in Location: header of CHECKOUT response
- 3. Client works on local copy of main.c
- 4. When done, client saves changes back to the server
 - PUT to the working resource
- 5. Then, CHECKIN of working resource
 - Turns working resource into a version

Baselines

Purpose of Baselines

- When a large collection of documents is released outside the developing organization, there is a need to record exactly which document versions were released.
 - Especially true for software project releases
- A baseline can record the exact version of a large set of resources under version control
- Baselines can also be used for recording intermediate project states
 - The state of the project as of last Friday
 - Quality assurance can then have a stable snapshot to work from

Baseline Definition

- A *baseline* is a special kind of version resource that captures the state of the version-controlled members of a configuration.
- A *baseline history* is a version history whose versions are baselines
 - Baselines are **versioned** and change over time
- New baselines are created by checking out and then checking in a special kind of version-controlled resource called a *version-controlled configuration*
 - Baselines thus have the same three resource data model as other resources under version control
 - Version history for baselines → baseline history
 - Version resources → baseline
 - Version controlled resource → version controlled configuration

Baseline Mechanics

- A collection is placed under **baseline control** using the BASELINE-CONTROL method
 - Example:
 - Source code for a project is in the /project/src/ collection
 - Apply BASELINE-CONTROL to /project/src/
- Creating a new baseline history:
 - BASELINE-CONTROL method:
 - Creates a new version controlled configuration
 - Puts its URL in *DAV:version-controlled-configuration* property of collection
 - Records association between baseline history and collection

Baseline Mechanics (2)

- Creating a new baseline:
 - CHECKOUT version controlled configuration
 - Makes the version controlled configuration changeable
- Taking a snapshot of a project:
 - CHECKIN the version controlled configuration
 - Creates a new baseline
 - I.e., a new version in the version history of baselines
 - Also creates a new collection...
 - ... in a **server-defined** portion of the namespace ...
 - ... which contains a set of version-controlled resources ...
 - ... each of which has the value of the most recently checked-in version in its version history.
 - Net effect:
 - The new collection is a **snapshot of the checked-in state** of the baselined collection at the moment of checkin

Baseline Details

- A workspace is defined to be a collection
 - Can place a workspace under baseline control
- It is possible to compare baselines
 - Use **compare-baseline** report
 - Invoke with REPORT method
 - Describes which versions have been added, removed, or changed

Features & Packages

Basic Features

- Protocol functionality is divided into:
 - Features
 - Assigned to be either Basic or Advanced
- Basic Features:
 - VERSION-CONTROL
 - Basic versioning
 - Automatic versioning only (no checkin or checkout)
 - REPORT method and version-tree report
 - CHECKOUT
 - Checkout, checkin, and uncheckout
 - VERSION-HISTORY
 - Version history resource has a URL in the server namespace
 - WORKSPACE
 - Server workspace functionality
 - WORKING RESOURCE
 - Client workspace functionality
 - UPDATE
 - LABEL

Advanced Features

- Advanced Features:
 - MERGE
 - Considered advanced due to workspace capabilities
 - BASELINE
 - Recording checked-in state of a collection
 - ACTIVITY
 - Versions associated with a logical change
 - VERSION-CONTROLLED-COLLECTION
 - Collections can be versioned
- Feature discovery is via OPTIONS
 - Each feature has an associated tag that appears in the DAV: response header
 - E.g.: VERSION-CONTROL feature → "version-control" in DAV response header
 - DAV: 1, 2, version-control

Packages

- Features are divided into packages.
 - Attempt to reduce the number of possible server feature permutations a client might encounter
- A basic versioning server should support one of the following feature sets:
 - **Core-Versioning**
 - VERSION-CONTROL only
 - **Basic-Server-Workspace**
 - VERSION-CONTROL
 - WORKSPACE
 - VERSION-HISTORY
 - CHECKOUT
 - **Basic-Client-Workspace**
 - VERSION-CONTROL
 - WORKING-RESOURCE
 - UPDATE
 - LABEL

Advanced Packages

- There are two packages for advanced features:
 - **Advanced-Server-Workspace**
 - Basic-Server-Workspace
 - Plus all advanced features
 - MERGE
 - BASELINE
 - ACTIVITY
 - VERSION-CONTROLLED-COLLECTION
 - **Advanced-Client-Workspace**
 - Basic-Client-Workspace
 - Plus all advanced features
- Thus, a client will likely encounter only servers that have implemented one of six packages

DeltaV Resources

WebDAV

- **WebDAV Resources**
 - <http://www.webdav.org/>
 - A central collection of pages and links to all things WebDAV.
- **WebDAV Working Group**
 - <http://www.ics.uci.edu/pub/ietf/webdav/>
 - Contains links to active documents, and a complete list of WebDAV-supporting applications.
- **RFC 2518 – WebDAV Distributed Authoring Protocol**
 - <http://www.ics.uci.edu/pub/ietf/webdav/protocol/rfc2518.pdf>
 - This is the WebDAV Distributed Authoring Protocol specification
- **WebDAV: A network protocol for remote collaborative authoring on the Web**
 - *Proc. of the Sixth European Conference on Computer-Supported Cooperative Work*, Sept. 12-16, 1999, Copenhagen, Denmark, pp. 291-310.
 - <http://www.ics.uci.edu/~ejw/papers/dav-ecscw.pdf>
 - An academic paper giving an overview of the WebDAV Distributed Authoring Protocol.

DeltaV

- **Delta-V Working Group web page**

- <http://www.webdav.org/deltav/>
 - The home page for the IETF Delta-V Working Group, with links off to the most recent specifications.

- G. Clemm, J. Amsden, C. Kaler, J. Whitehead, "**Versioning Extensions to WebDAV**", Internet-Draft, work-in-progress, draft-ietf-deltav-versioning-15, April 17, 2001.

- <http://www.webdav.org/deltav/protocol/draft-ietf-deltav-versioning-15.htm>
 - The most recent revision of the versioning and configuration management protocol specification.

- **The Future of Distributed Software Development on the Internet**

- Web Techniques, Vol. 4, No. 10, October, 1999, pages 57-63
- <http://www.webtechniques.com/archives/1999/10/whitehead/>
 - An introduction to WebDAV and DeltaV that describes the advantages of DeltaV over CVS for remote collaborative software development

